Update on the Electron Cap-ECAL MC simulation

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Description of the activity

Ultimate goal: Study of the Electron Cap ECAL performance and optimization of the detector

We are working on :

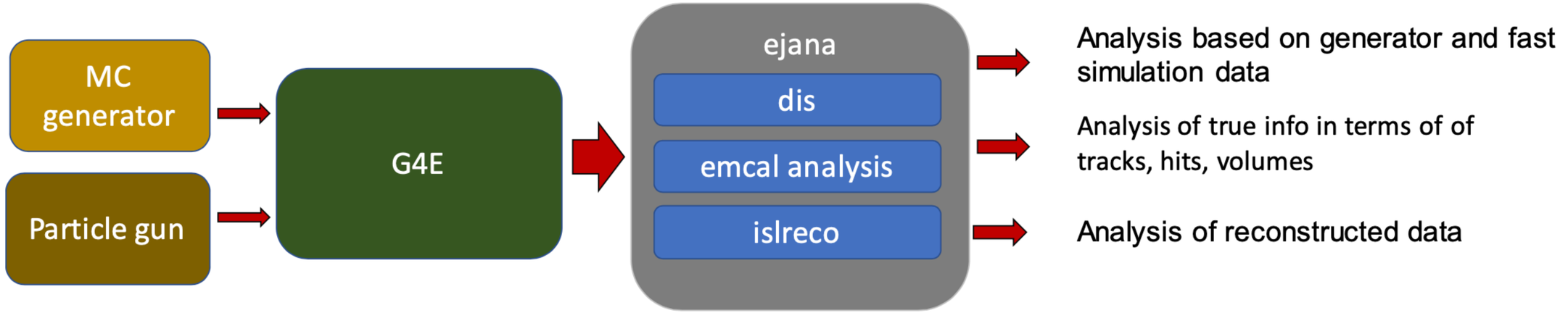
★ Implementation of the Electron Cap-ECAL in g4e :
- Geometry
- Digitization

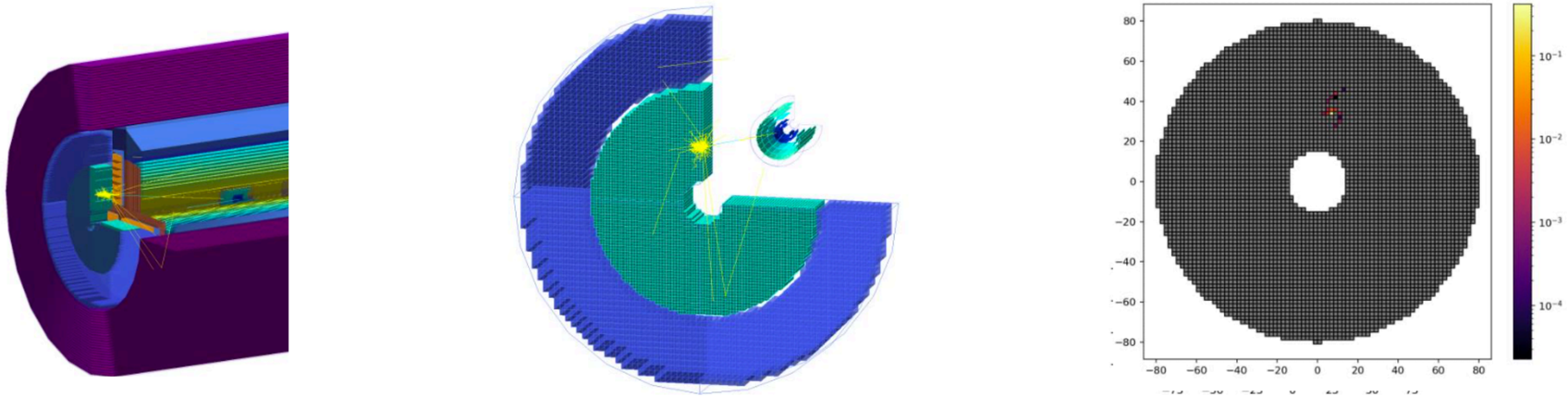
★ Reconstruction algorithm in EJANA framework **Working in progress**

★ Analysis plugins in EJANA for study the Electron Cap ECAL performance **Working in progress**
- Energy resolution
- Effect of the Ecal resolution on reconstructed quantities like Q^2, x

★ AI optimization based on the approach described in https://iopscience.iop.org/article/10.1088/1748-0221/15/05/P05009/meta **Working in progress**

g4e + ejana simulation and recon





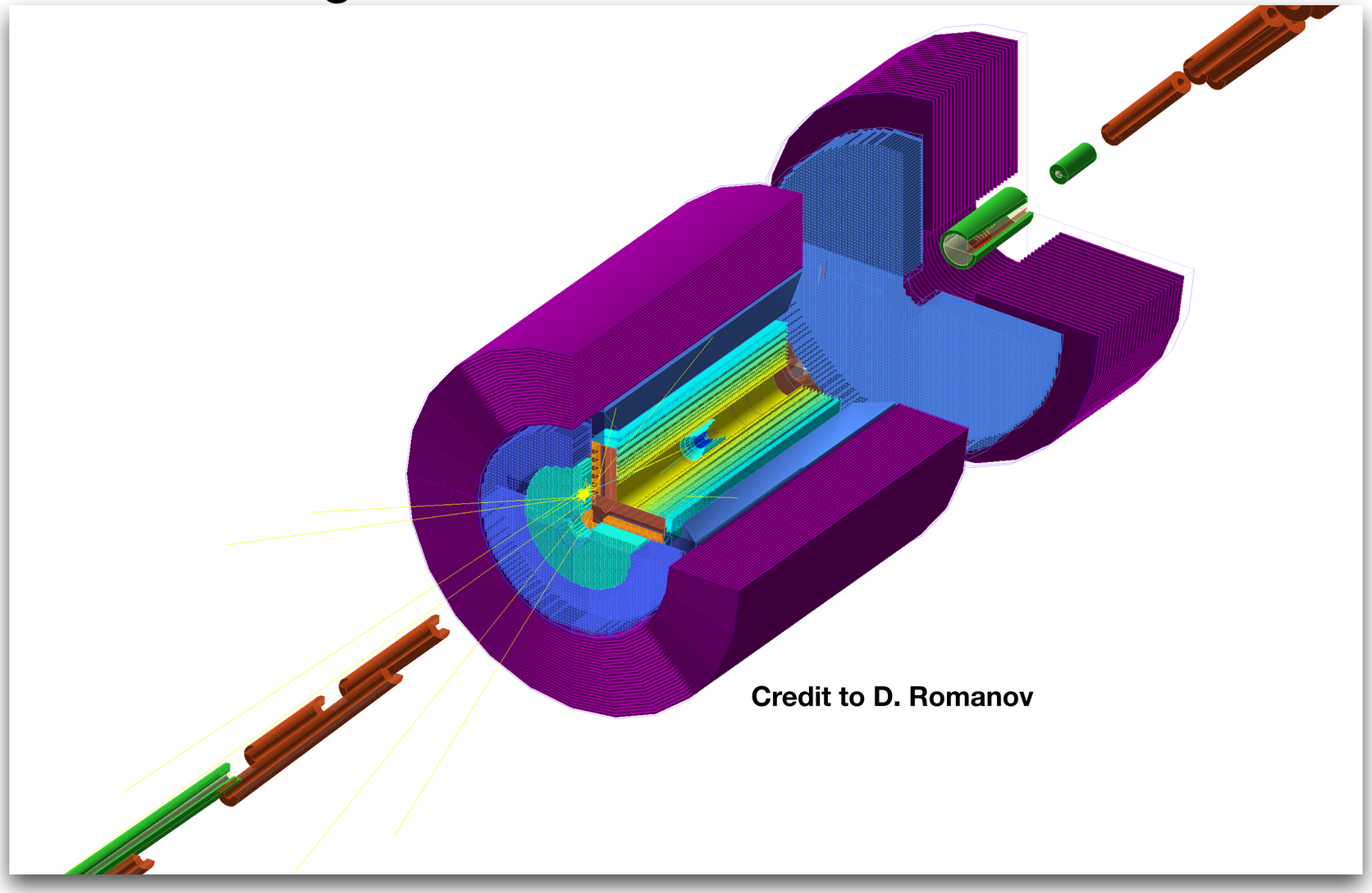
A hit in electron endcap calorimeter. Simulated with g4e particle gun

https://gitlab.com/eic/escalate/plugins/calorimetry_studies

Credit to D. Romanov

MC simulation : geometry

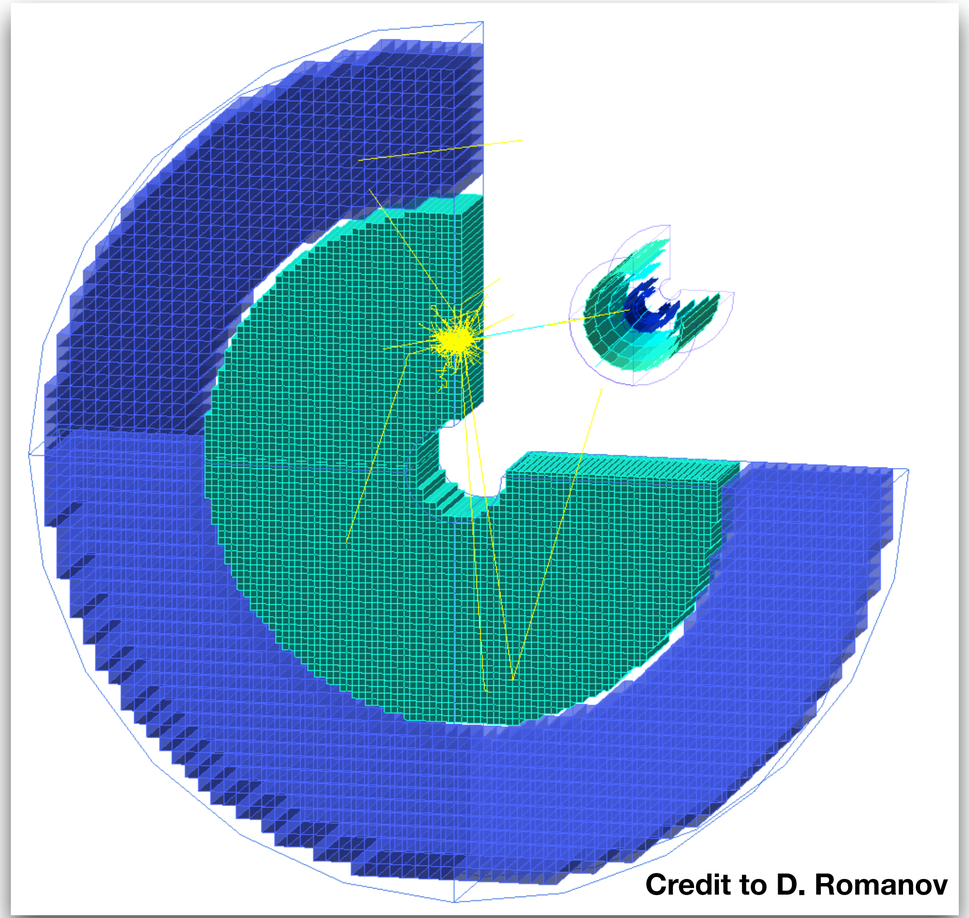
Detector in g4e



Credit to D. Romanov

MC simulation : geometry

Electron cap ECAL in g4e



Homogenous calorimeter :

➡Inner part:

- Rin = 20 cm, Rout = 82 cm
- PbWO4 crystals: 20 x 20 x 200 mm^3

➡Outer part:

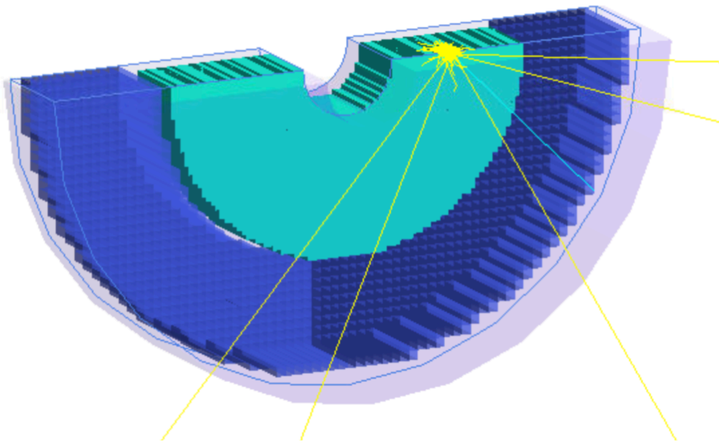
- Rin =85 cm, Rout = 133 cm
- DSB:Ce: 40 x 40 x 400 mm^3

MC simulation : Digitization

Description of the response of a crystal coupled to a SiPM is implemented in g4e, based on the experience gained with CLAS12-FT in HALLB and BDX**:**

- Estimate of the total deposited energy Etot = ΣE_i
- Estimate the number of photons generated in the scintillator and reached the crystal surface: $N\gamma = Etot * LY$
- Estimate the number of photons hitting the sensor surface $N\gamma = N\gamma*(Asensor/Acrystal)$
- Estimate the number of photo-electrons Npe taking into account the SiPM saturation effect: $Npe = Ncells * (1 - \exp(- N\gamma *PDE/Ncells))$ (F. Acerbi et al. NiMA 926(2019)16
- Number of pe is extracted randomly according to a Poisson distribution with mean equal to Npe

First results



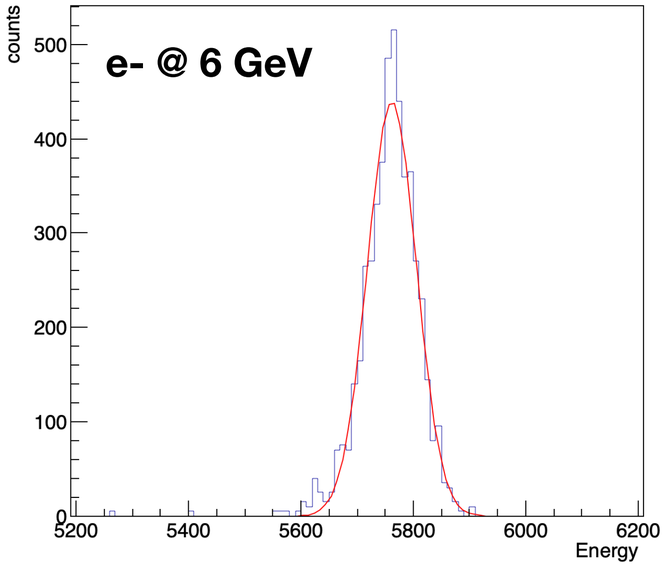
The response of the inner part (PbWO4 +SiPM) to electrons was evaluated

Crystal:

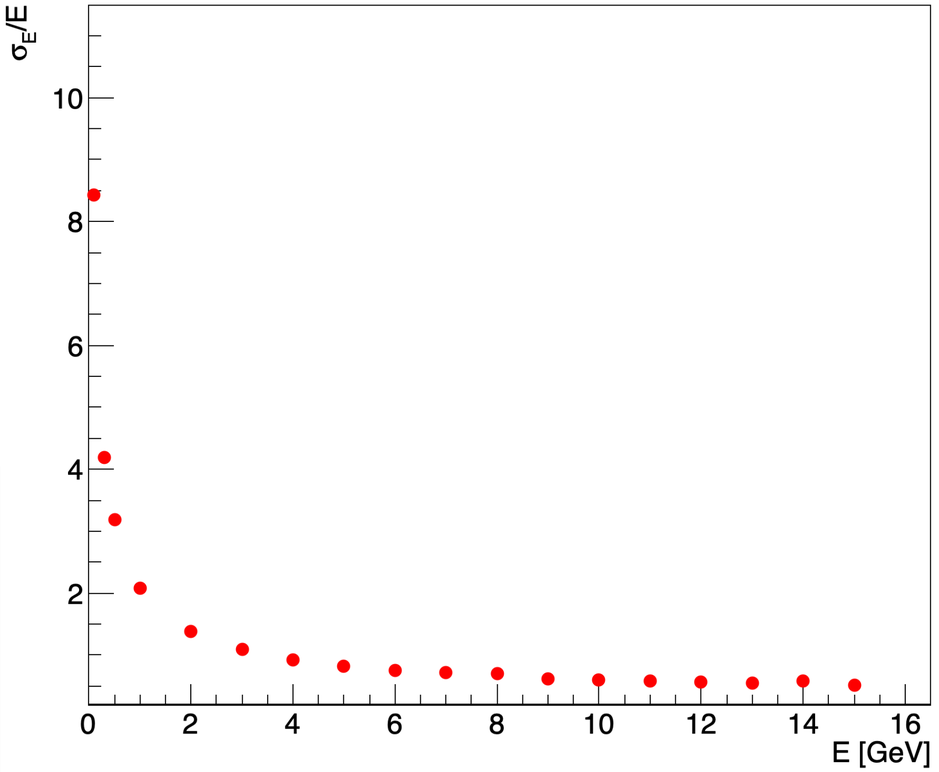
- Material: PbWO4
- Size: 2x2x20 cm^3
- LY : 240 γ/MeV

SiPM:

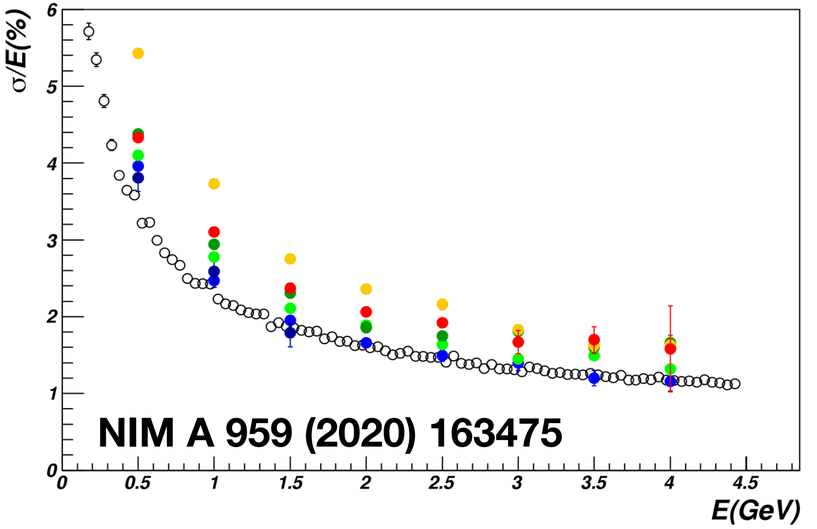
- Area: 1.2 x 1.2 cm^2
- pixel pitch: 25 um^2
- PDE: 0.22



Energy Resolution



Energy Resolution - CLAS12 FT

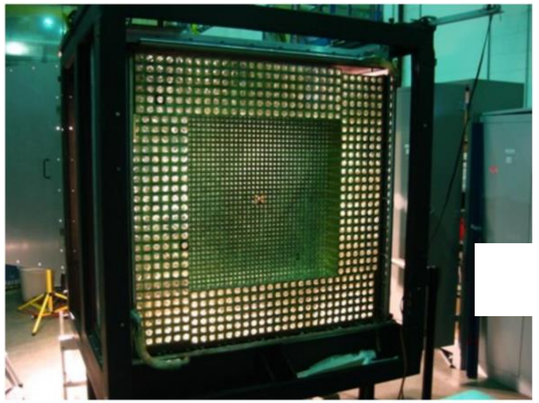


Energy resolution in agreement with expected value

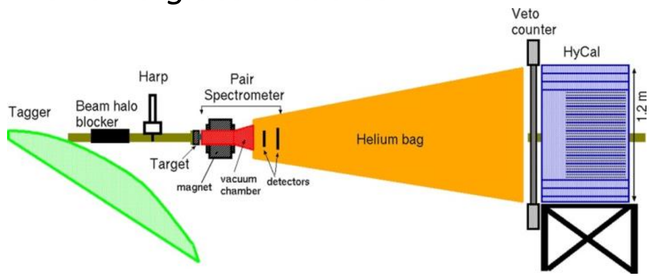
Reconstruction algorithm in EJANA framework

Islreco reconstruction algorithms

- The main **developer is Ilya Larin**. Now the librarty is rewritten to C/C++ and publically available at: https://github.com/emcal/islreco
- **Island method clusterization** is combined with common reconstruction algorythms
- **Can be used for hybrid calorimeters**
  (The main author has 20+ years of experience with hybrid calorimeters)
- **Has many features.** E.g. can receive X,Y coordinates from tracking for better cluster separation and more.
- **Used in existing experiment**s:
  - SELEX (Segmented Large X baryon Spectrometer) Fermilab
  - PrimEx-II (JLab HallB)
  - PrimEx-D (JLab HallD)
  - Many publications based on reconstructions that embedded this library (Fermilab list, JLab list).



HyCal hybrid calorimeter with
1152 $PbWO_4$ modules
576 Pb-glass modules



Precision measurement of the neutral pion lifetime
American Association for the Advancement of Science
By I. Larin, Y. Zhang, A. Gasparian, L. Gan, at all. 2020

Credit to D. Romanov

Analysis plugins in EJANA

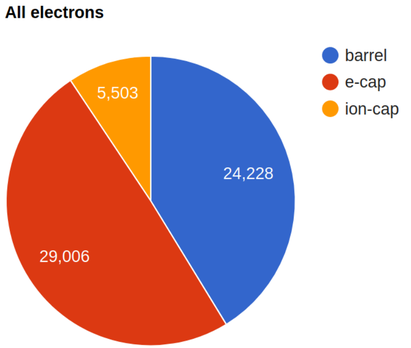
Study the effect of the ECAL resolution on DIS reconstructed quantities:

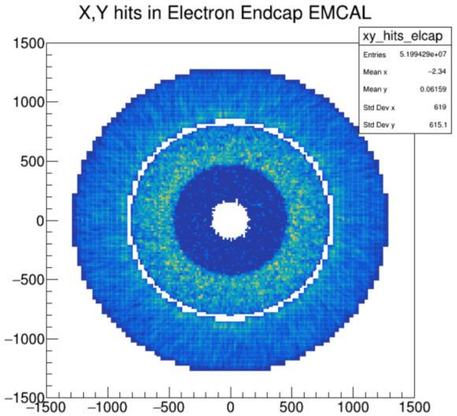
Electrons multiplicity (based on Beagle data)

```
events count : 39735
```

All electrons:

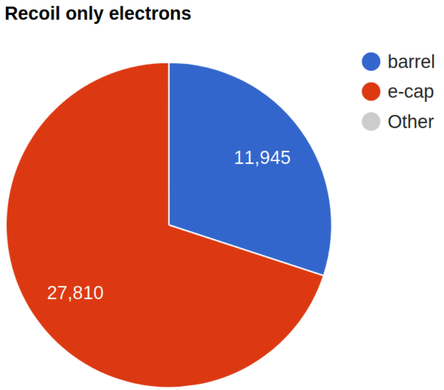
```
barrel  : 24228
e cap   : 29006
ion cap : 5503
```





Recoil only electrons:

```
barrel  : 11945
e cap   : 27810
ion cap : 2
```

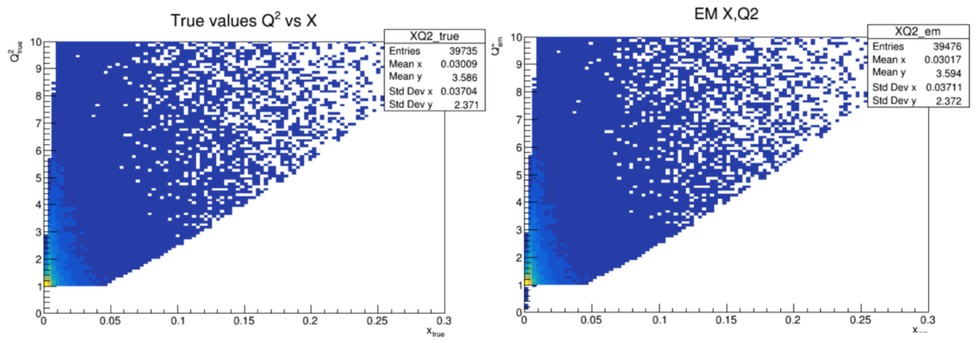


Credit to D. Romanov

Analysis plugins in EJANA

Study the effect of the ECAL resolution on DIS reconstructed quantities:

True values obtained from the generator



Reconstructed X and Q2 with EM method from true tracks which hit **any of central calorimeters**

Resolution in Q2 e X related to the angle and energy resolution

Reconstructed X and Q2 with EM method from true tracks which **hit electron cap emcal**

Q2 reconstructed vs true electron cap emcal

Credit to D. Romanov

- Reconstructed kinematic variables calculated solely from the scattered e- (EM method)
- Q^2_{EM} and X_{EM} are calculate using the e- information (E, θ) from the tracks no the reconstructed ones (not yet!).

Summary

★ Synergy between "R&D on Homogeneous Calorimeter Materials for EIC using Crystals and Glasses” group and EIC Software group

★ Implementation of the Electron Cap ECAL in g4e is ready.

★ Calorimeter reconstruction will be soon releasing.

★ Analysis plugins under development.

★ As soon as the previous items will be completed, the optimization activity based on AI will start